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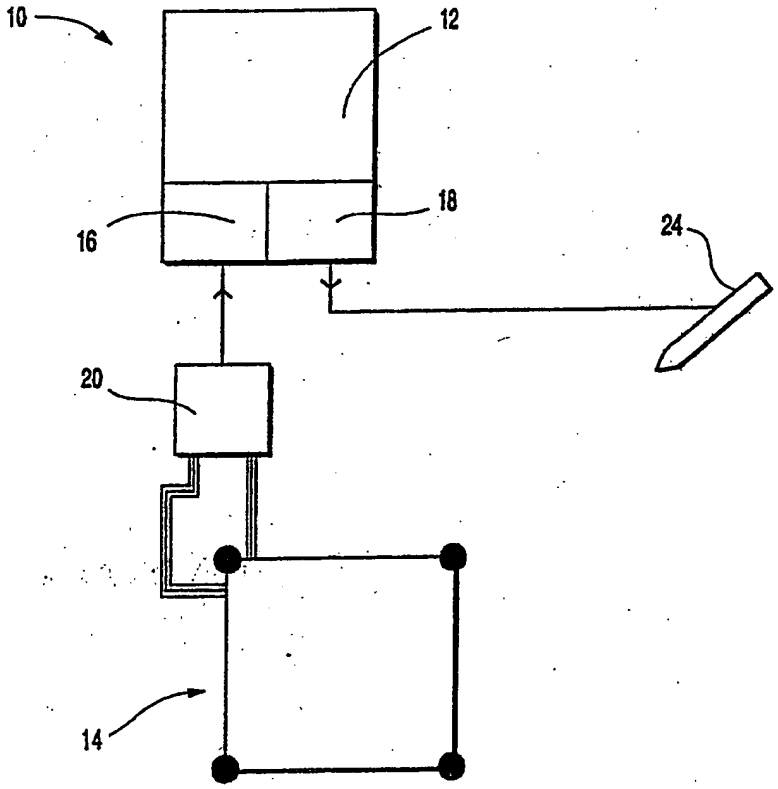
(54) Title: INPUT DEVICE WITH TACTILE FEEDBACK



(57) Abstract

A computer system comprising means for displaying output to the user and means for enabling a user to provide input by selecting positions on the input means characterised by means for providing tactile feedback to a user according t the selected positions.

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INPUT DEVICE WITH TACTILE FEEDBACK

The present invention relates to computer user interfaces.

Presently available computer user interfaces are many and varied. Several graphical user interfaces are available and most of these are windows-based, eg, XWindows, MSWindows. Generally, particular areas of the screen have special significance in enabling the user to make selections and perform tasks. For example, the user may be presented with soft function keys, icons representing applications or work items, windows having borders with sections for sizing, scrolling, etc. Often, selection of such screen areas is accompanied by visual feedback for the user, such as a colour change or flashing effect. It is also known to provide audible feedback in some systems, such as a selection of particular icons.

It is also common to provide an accessory for enabling a user to provide input to a computer system, such as a touch screen overlay or a digital tablet. In the case of a digital tablet or other input accessory separate from the output display screen the user may make selections by touching the surface of the accessory. The surface of the accessory may correspond to the screen surface to allow a user to make selections from displayed output or may be independent of the displayed output, eg, in a CAD system.

The present invention aims to provide an improvement relating to computer user interfaces.

According to the present invention we provide a computer system comprising means for displaying output to a user and means for enabling a user to provide input by selecting positions on the input means characterised by

means for providing tactile feedback to a user according to the selected positions.

The provision of tactile feedback enhances a user interface from the human perspective and can be used to provide additional information to the user.

Preferably, the system comprises means for varying the tactile feedback according to the selected positions. For example, the tactile feedback given when a user selects a soft function key may be different from that given when an icon is selected.

In the embodiments to be described, the system comprises means for providing vibrational tactile feedback to a user. Preferably, the system comprises means for varying the frequency and/or amplitude of the vibrational tactile feedback according to the selected positions. Humans are sensitive to low frequency vibration and a preferred system comprises means for giving vibrational tactile feedback at a frequency of less than 200 Hertz to a user.

The feedback may be continuous vibrational feedback or pulsed vibrational feedback. In the latter case, varying the pulse envelopes may alter the effect experienced by a user.

Preferably, the system comprises means for varying one or more characteristics of the vibrational feedback in dependence upon the speed of movement of the user across the surface of the input means. This feature is particularly relevant in providing textural feedback and/or edge effects to a user as the user moves across the surface of the input means.

The system may be configured to enable the user to provide input using a movable input device, such as a stylus or a mouse. In a preferred embodiment, the movable input device comprises means for providing tactile feedback to a user.

The input means may be integral with the screen so that a user can provide input by touching the screen.

Alternatively, the system may comprise input means in the form of an accessory having a surface corresponding to all or part of the screen and configured to enable a user to provide input to the system by touching the surface of the input means. The input means may be adapted to respond to human touch or to the touch of an input device, such as a stylus.

The term "touching" in this context shall be taken to cover close proximity as well as actual contact, eg, a light pen may not need actually to make contact with a screen to have effect.

In a further embodiment to be described, the input means comprises means for providing tactile feedback to a user. Preferably, the system comprises means for vibrating the input means.

The input means may comprise the screen of a touch-screen computer system or a touch-screen overlay for a computer screen. Alternatively, the input means may comprise an accessory, such as a digital tablet.

Particular embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which :

Fig 1 shows a c mputer system according to a first embodiment of the present invention;

Fig 2 shows a second embodiment of a computer system according to the present invention;

Figs 3A/B show two embodiments of a stylus for use in a computer system of the present invention;

Fig 4 shows a mobile workstation according to the present invention;

Fig 5 is another embodiment of a computer system according to the present invention;

Fig 6 is a vibration graph.

Figure 1 shows a computer system indicated generally at 10 comprising a work station 12 and touch sensitive input means 14. The workstation has a serial input/output (i/o) card 16 and a digital to analogue converter (D/A) board 18. A touchscreen driver 20 is connected between the input means 14 and the serial i/o card 16 of the work station 12.

The input means 14 is a touch sensitive transparent plate which is flexibly mounted at three corners and which has a vibrating mechanism 22 attached to the other corner. The vibrating mechanism is a speaker coil which receives signals from the D/A board 18. The input means is designed to overlay a video or LCD display (not shown) which receives output from the workstation so that a user can touch the input means 14 to select items on the underlying display. The input means may be sensitive to the touch of a user's finger or a stylus.

In use, tactile feedback is provided to a user accordingly to choices made by the user by selectively vibrating the input means 14. Signals from the touchscreen driver 20 are processed by the workstation 12 in the following manner:

PSEUDO CODE	COMMENTS
repeat	
read RS232 port	get touch position continuously fed from touch sensor
which area of the screen is touched?	
speed = rate of change of position	non zero if touch has been continuous
icon: make icon vibration (speed)	most vibrations will need speed info
document: make document vibration (speed)	
button: if last position = not touching screen then	
make button depression vibration	button depression event
else make button vibration (speed)	just sliding over button
background: make background vibration (speed)	screen background has a texture too
etc	other graphics elements handled here
not touching: make no vibration	
until done	keep on reading touch and responding

The system is configured to provide tactile feedback which varies according to which part of the displayed output is selected by the user and also according to how the user touches the input means 14, eg, whether the user's finger or stylus is still or moving across the surface of the input means 14. The vibrational feedback generated when an icon is selected may well be different from that generated when a document or button is selected. The variation in feedback is achieved by varying the frequency and/or amplitude of the vibration and/or the frequency and/or envelope of pulses if pulsed feedback is being given.

Humans are touch sensitive to relatively low frequencies and frequencies in the range 20Hz - 200 Hz are appropriate. A continuous wave will feel different to a user depending on the frequency because different standing waves are generated in the user's finger or stylus. The amplitude of the vibration can be varied from that which is barely discernible to that which is audible. For certain items, eg, buttons, the feedback may be such that a physical click is both heard and felt by the user.

Pulsed waveforms can be used to give subtlety to the feedback. Pulses of more than 2ms duration sound and feel more complex to a user.

It is possible to convey a sense of texture to a user using different noise spectra. Texture can only be felt if the user's finger or stylus is moving across the surface of the input means 14 and the speed of movement is a parameter which is used to generate feedback. Textural vibration is zero when the user's finger or stylus is stationary and increases with the speed of movement of the finger or stylus across the surface of the input means. In this way it is possible to provide edge effects to a user as well as different surface texture effects.

Referring to Figure 1, the touch sensitive input means 14 may alternatively be a transparent overlay for the screen of the workstation 12 with means for attaching the input means to the visual display unit of the workstation 12. Another alternative is for the touch sensitive input means 14 to be the actual display screen of the workstation in which case input and output means are combined and the vibration mechanism is built into the workstation casing.

A further alternative is for the touch sensitive input means to be incorporated in a digital tablet. Digital tablets are commonly used in computer aided design systems. To facilitate the selection between very many alternative design components, it is possible to use overlays for the digital tablet for certain classes of component, eg, one overlay for resistors and another for capacitors in a CAD system for designing circuit boards, and to switch the input mode according to the chosen overlay. In such a case, the digital tablet could be configured to provide tactile feedback to simulate the depression of buttons for each choice. In this example, selection of a position on the input means (digital tablet) does not necessarily correspond to a particular position on the output display of the system.

Referring to Figure 2, in another embodiment the touch sensitive input means is responsive to input from an active stylus 24. In this embodiment, the stylus comprises a vibrating mechanism and the input means 14 does not. Otherwise, the reference numbers for the components are the same as in Figure 1.

The stylus 24 receives signals from the D/A board 18 and vibrates in accordance with these signals to provide tactile feedback to the user. In the previous discussion on different aspects of tactile feedback, the same points apply

whether the user is sensing the feedback by touching vibrating input means directly or with an ordinary stylus or whether the user is holding an input device, such as a stylus, which vibrates.

Figures 3A and 3B show alternative stylus vibrating mechanisms. In Figure 3A a stylus 24a comprises a solenoid 26 which is attached to a spring-mounted weight 28 housed within the body of the stylus. On receipt of signals from the D/A board 18, the solenoid 26 causes the weight 28 to vibrate as indicated by the arrows which vibration is felt by a user holding the stylus. In Figure 3B, a stylus 24 b comprises a solenoid 30 which is attached to a spring-mounted tip 32 of the stylus. On receipt of signals from the D/A board 18 the solenoid 30 causes the tip 32 to vibrate to provide tactile feedback to a user. Stylus tip vibrations are suitable for conveying precise edge detail to a user.

Figure 4 shows a mobile workstation 35 comprising a stylus 36 and a touchscreen 38. The workstation 35 is designed to accept stylus input and to provide tactile feedback to a user via a vibrating mechanism in the stylus 36.

Another embodiment of the present invention is shown in Figure 5 in which a computer system indicated generally at 40 comprises a workstation 42 provided with a serial i/o card 44 and a D/A board 46. The workstation 42 is configured to receive input from a mouse 48 and to provide tactile feedback to a user by means of signals from the D/A board 46 to a vibrating mechanism (not shown) comprising a solenoid attached to a spring-mounted weight within the casing of the mouse 48.

Figure 6 combines two graphs indicating certain measurements which it is useful to make when designing a

system according to the present invention. One is a graph of frequency of vibration against the voltage used to drive a speaker coil needed for the vibration to just be able to b felt (both axes ar non-linear scales). This is the "threshold of feeling" curve. The second graph is of frequency against a (subjective) strength of feeling scale to produce the "strength of feeling" curve. The full black lines are simplified approximations of these two curves.

The graph shows that the threshold of feeling generally decreases as frequency increases. In terms of volts used to generate vibration, the strength of feeling increases with increasing frequency to around 40Hz, stabilises and then begins to decrease markedly beyond 120Hz.

It will be appreciated that the present invention is applicable to various types of computer system whether the user works at a terminal connected to a host computer or an intelligent workstation such as a PC which stands alone or is part of a computer network.

The vibrating mechanism which is employed to provide tactile feedback may be chosen according to requirements. Embodiments utilising a solenoid and a speaker coil have been described but it is also possible to use a piezo-electric device or other vibrating mechanism.

CLAIMS

1. A computer system comprising means for displaying output to the user and means for enabling a user to provide input by selecting positions on the input means characterised by means for providing tactile feedback to a user according to the selected positions.

2. A system according to claim 1 comprising means for varying the tactile feedback according to the selected positions.

3. A system according to claim 1 or claim 2 comprising means for providing vibrational tactile feedback to a user.

4. A system according to claim 3 comprising means for varying the frequency and/ or amplitude of the vibrational tactile feedback according to the selected positions.

5. A system according to claim 3 or claim 4 comprising means for providing vibrational tactile feedback at a frequency of less than 200 Hertz.

6. A system according to any one of claims 3 to 5 comprising means for providing continuous vibrational feedback to a user.

7. A system according to any one of claims 3 to 5 comprising means for providing pulsed vibrational feedback to a user.

8. A system according to any one of claims 3 to 7 comprising means for varying one or more characteristics of the vibrational feedback in dependence upon the speed of movement of the user across the surface of the input means.

9. A system according to any preceding claim configured to enable the user to provide input using a movable input device.

10. A system according to claim 9 in which the movable input device comprises means for providing tactile feedback to a user.

11. A system according to claim 10 wherein the input device is a stylus.

12. A system according to claim 10 wherein the input device is a mouse.

13. A system according to any preceding claim wherein the input means is integral with the screen so that a user can provide input by touching the screen.

14. A system according to any one of claims 1 to 12 comprising input means in the form of an accessory which is configured to enable a user to provide input to the system by touching a surface of the input means.

15. A system according to claim 14 wherein the input means comprises an overlay for the screen.

16. A system according to claim 14 wherein the input means comprises an accessory separate from the screen.

17. A computer system according to claim 16 wherein the accessory is a digital tablet.

18. A system according to any preceding claim wherein the input means comprises means for providing tactile feedback to a user.

19. A system according to claim 18 comprising means for vibrating the input means.

20. A system according to any one of claims 13 to 19 wherein the input means is adapted to respond to human touch.

21. A system according to any one of claims 13 to 19 wherein the input means is adapted to respond to the touch of an input device.

FIG 1

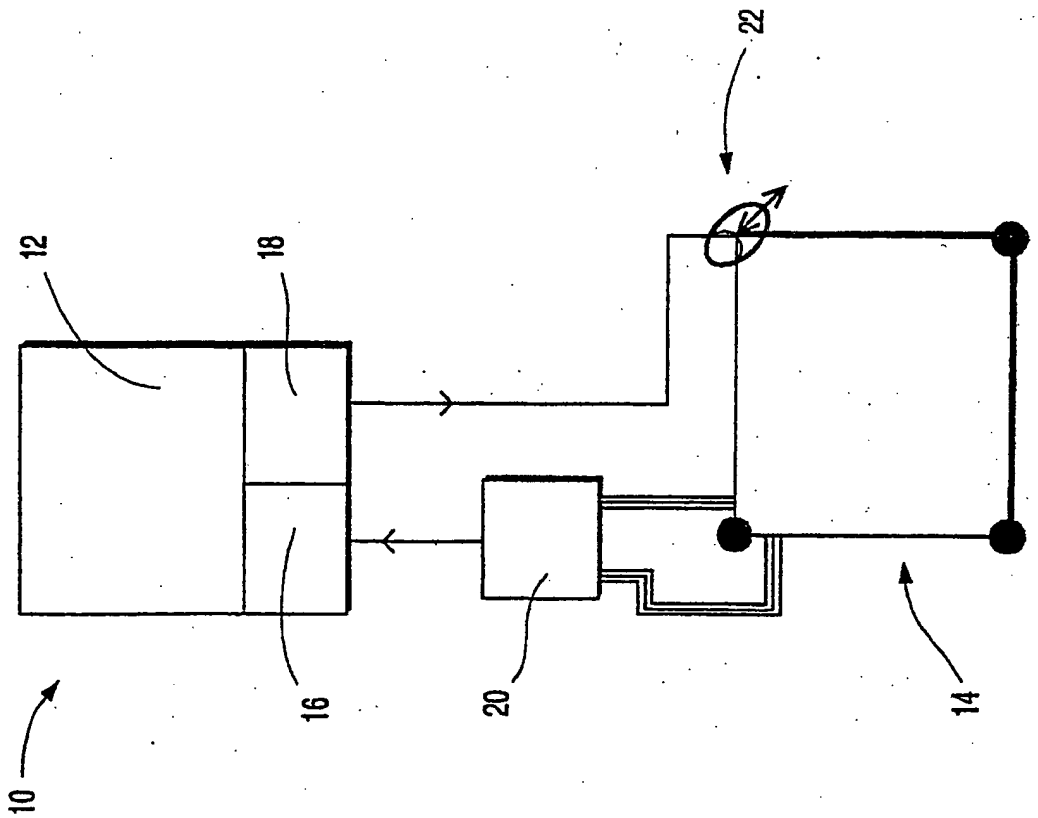


FIG 3A

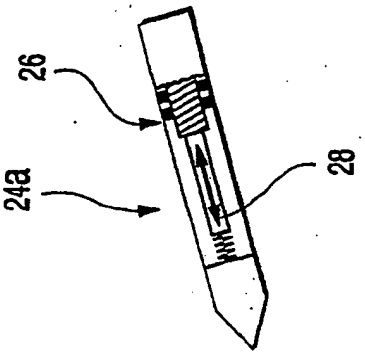


FIG 3B

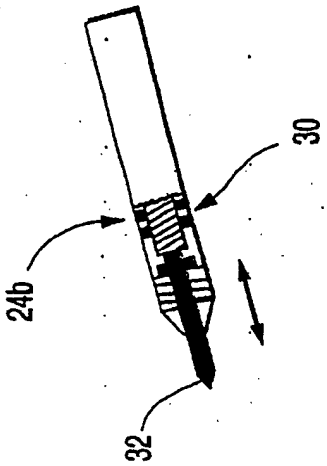
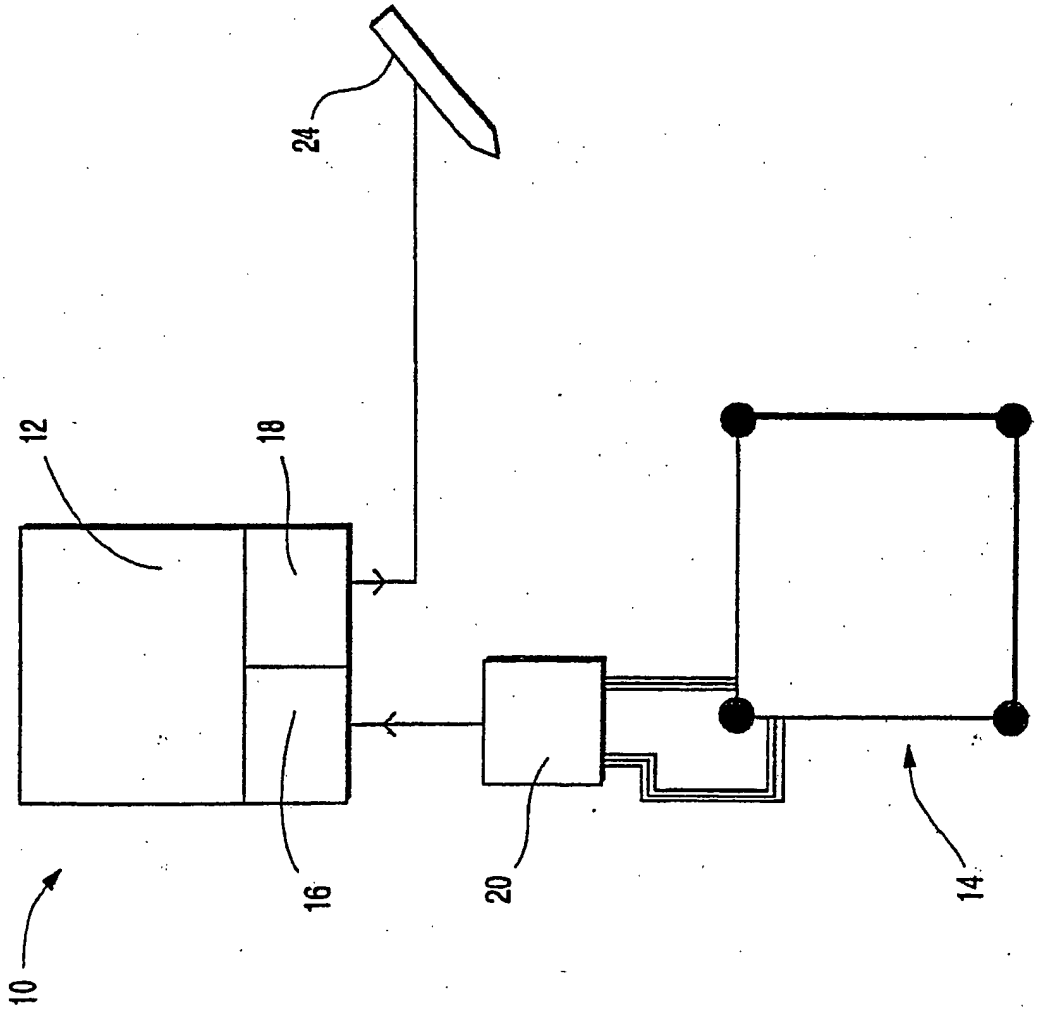


FIG 2



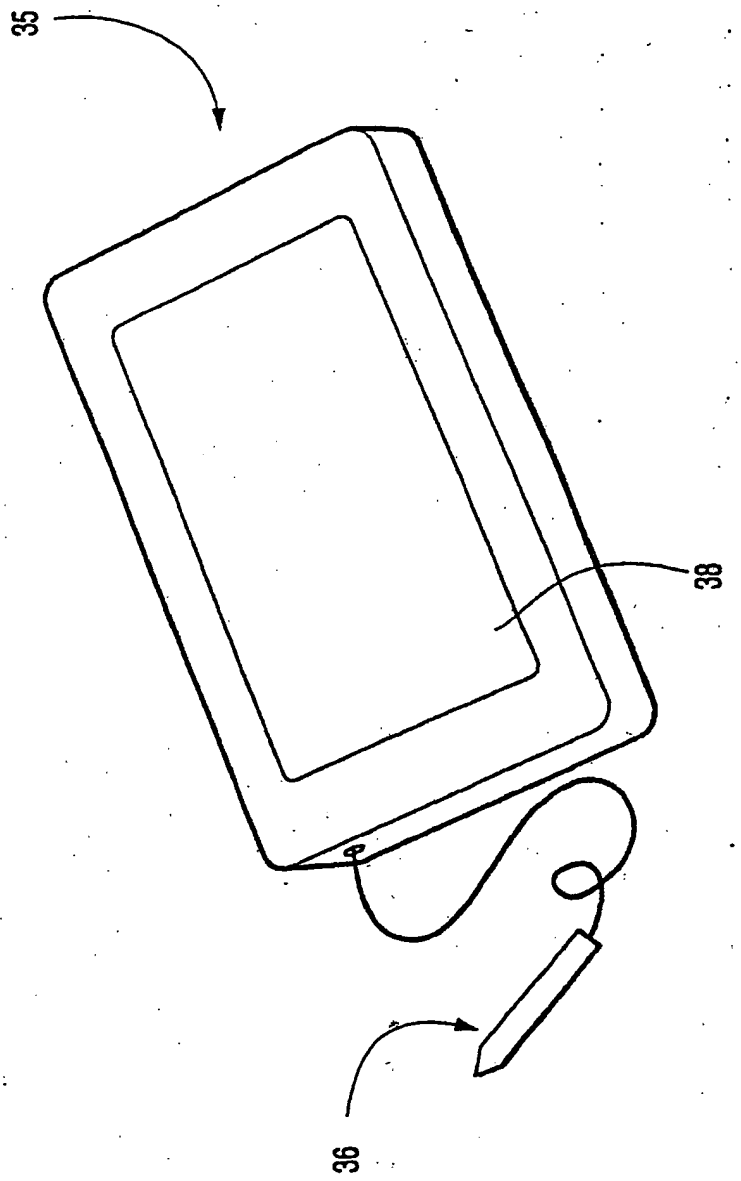


FIG 4

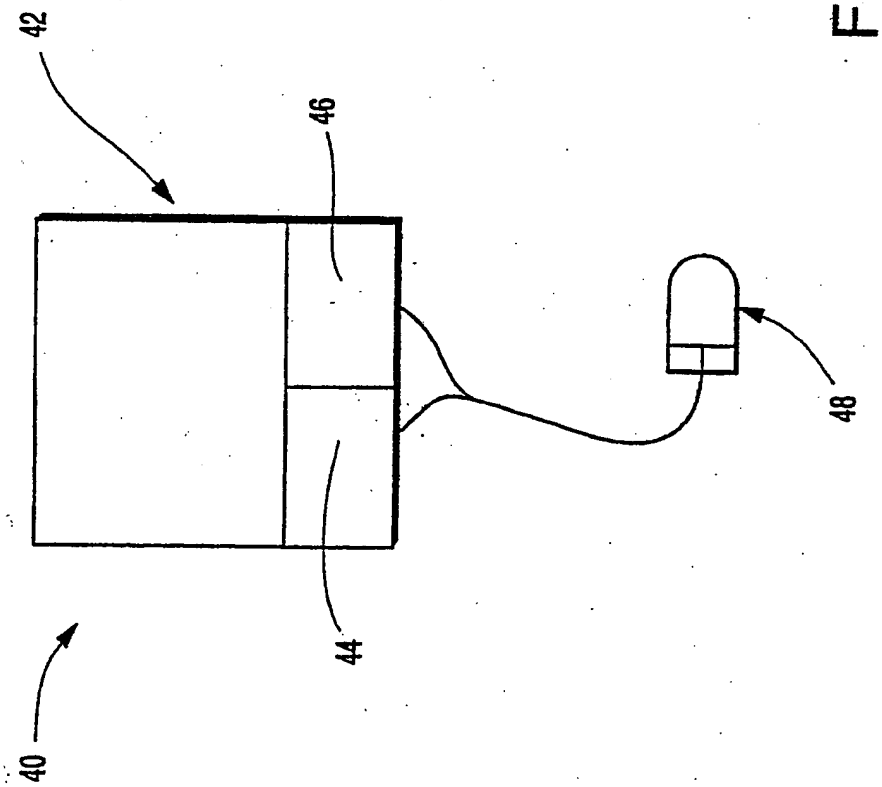


FIG 5

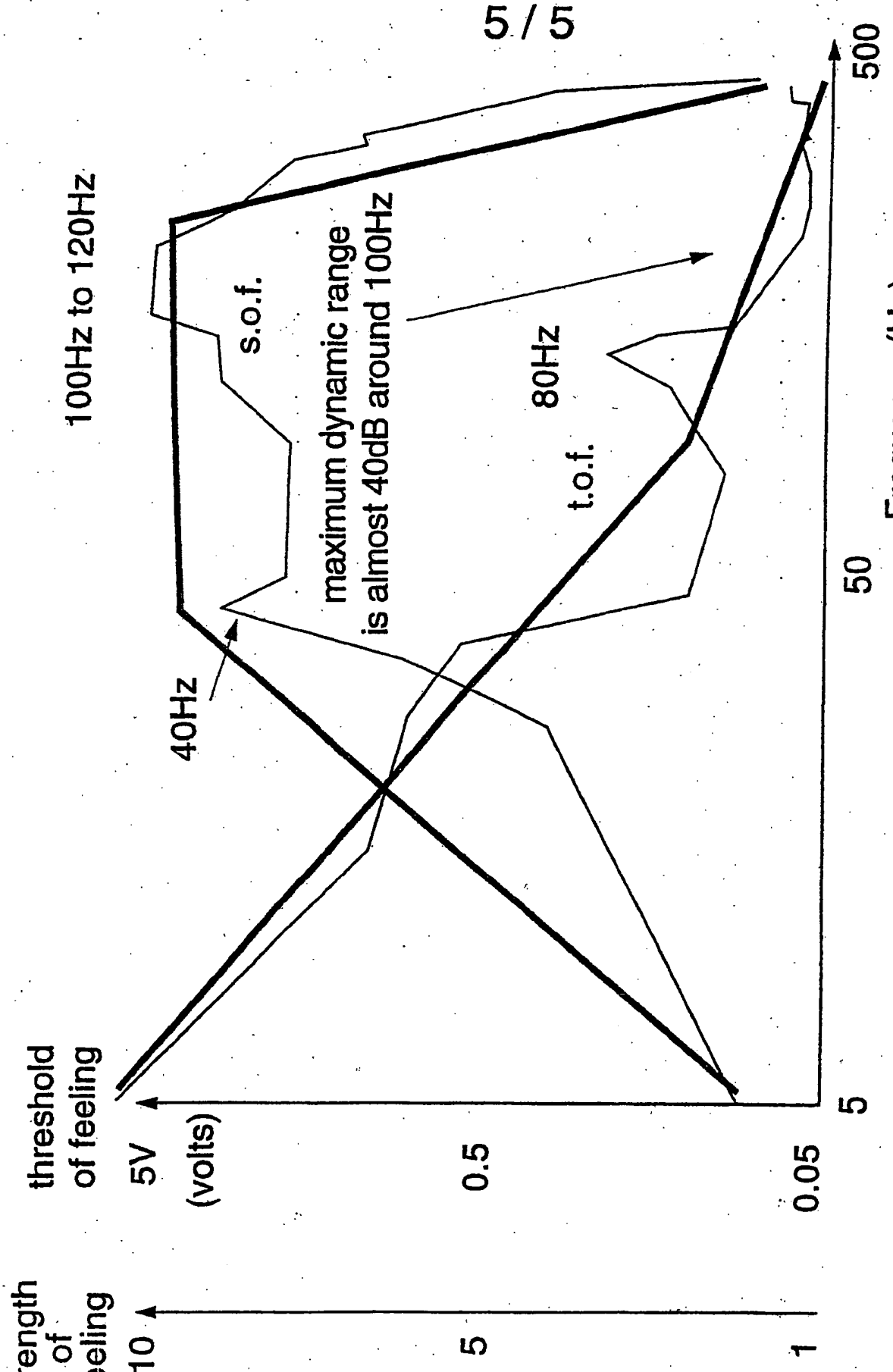

strength of feeling
10
5
1
threshold of feeling
5V
(volts)
0.5
0.05
5
50
500
Frequency (Hz)
100Hz to 120Hz
s.o.f.
maximum dynamic range is almost 40dB around 100Hz
40Hz
80Hz
t.o.f.

FIG 6

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00889

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G06F3/033 ; G06K11/18

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G06F ; G06K ; G06F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	IBM TECHNICAL DISCLOSURE BULLETIN. vol. 32, no. 9B, February 1990, NEW YORK US pages 230 - 235; 'Mouse ball-actuating device with force and tactile feedback ' see page 234, line 1 - line 21 see page 235, paragraph 5 ---	1-4,9, 10,12
X	US,A,4 885 565 (J.T. EMBACH) December 5, 1989 see abstract see column 1, line 34 - line 39 see column 2, line 3 - line 9	1,13,20
A	--- -/—	14,15

° Special categories of cited documents :[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29 AUGUST 1991	9. 10. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Patricia Smith

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	PROC. OF THE 14TH ANNUAL NORTHEAST BIOENGINEERING CONF. March 11, 1988, DURHAM, NH, US pages 146 - 149; J.A. TERRY ET AL.: 'Tactile feedback in a computer mouse' see page 146, left column, line 1 - line 8 see page 146, right column, paragraph 3 see page 146, right column, line 1 - line 9 ---	1,3,5,9, 10,12
X	EP,A,0 116 730 (IBM CORP.) August 29, 1984 see abstract see page 6, last paragraph - page 7, paragraph 1 ---	1,9-11

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9100889
SA 47984

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
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23/09/91

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4885565	05-12-89	None	
EP-A-0116730	29-08-84	JP-A- 59142640 US-A- 4667182	15-08-84 19-05-87